MODULAR CAUSEWAY FERRY

ROLL ON/ROLL OFF DISCHARGE

FACILITY ANALYSIS

CONTRACT NO. DAAK01-96-P-0219

PREPARED FOR:

U.S. ARMY
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August 29, 1996

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REVISION SHEET

REV.	DATE	Q.A.	APPR'D	DESCRIPTION
---	8/29/96		WJK	Initial Issue

August 29, 1996

REPORT SUMMARY

BACKGROUND

Lake Shore, Inc. Was tasked to evaluate the platform and connector adequacy of the Roll-on/Roll-off discharge facility (RRDF). The need for this evaluation was to support the Operational Testing of the Large Medium Speed Roll-on/Roll-off (LMSR) ship which is being performed in August and September in the Hampton Roads/Cape Henry area. Early calculations performed with limited engineering data indicated some areas of concern on platform size and capacities. Specific areas of concern were the hard point connector loadings under specific heavy loads and long-term fatigue of the connectors under heavy sea states.

CONFIGURATION

The RRDF platform considered consists of six Modular Causeway Ferry (MCF) sections assembled into a 160' long by 72' wide platform by joining two-three section wide platforms (80' x 72' each) using the standard N/L Flexor/Shear System. A seventh Sea/Beach end section is joined to one platform end on centerline using the same N/L Flexor System for cargo transfer to lighterage.

See Figure 1.

LOADING AND SEA CONDITIONS

The loadings and sea conditions that were analyzed are summarized in table 1.

TABLE 1

LOADING CONDITIONS AND SEA CONDITIONS

LOAD DESCRIPTION		SEA CONDITION			
		Calm	72' Transverse Wave	100' Diagonal Wave	100' Longitudinal Wave
Stern Ramp Configuration - Ramp Centered					
LSC1	Two Tanks on Ramp	Yes	Yes	Yes	Yes
LSC2	One Tank on Ramp-One Tank just off Ramp	Yes	Yes	No	No
LSC3	Two Tanks off Ramp-Centered on Hinge	No	Yes	No	No
LSC4	Two Tanks off Ramp STBD side inboard RRDF	Yes	No	No	No
Stern Ram Configuration - Ramp Moved 20' Outboard					
LSC5	Two Tanks on Ramp	Yes	No	No	No
Side Ramp Configuration					
LSC6	Two Tanks on Ramp	Yes	Yes	No	No
LSC7	Two Tanks Off Ramp-Centered on inboard end of inboard Platform	Yes	Yes	No	No
No Tank Configuration					
LSC9	Stern Ramp Configuration		Yes	Yes	Yes
LSC10	Side Ramp Configuration		Yes	No	No
LSC11	No Tanks or Ramp		Yes	Yes	Yes

NOTE:

- "Yes" Indicates Analysis Performed
- "No" Indicates Analysis Not Performed
- A Dynamic Load Factor of 1.25 G's was applied to ramp and tank weights for load cases on waves.

Weights and Dimensions were as follows:

40' MCF Center Modules	22,400#
20' MCF Raked End Modules	12,500#
Stern Ramp Weight	324,800#
Stern Ramp CG	68.41' From Ship Pivot Point
M1A1 Tank Weight	140,000#
Spacing of Tanks	22.3' From End of Track to Center of Track of next Tank
Wave Height	4.1'
Wave Length	Varies See Table 1

Enclosure "A" contains data on footprints of ramp end and tank treads.

ANALYSIS

A finite element analysis was performed to determine connector pin loads in the transverse and longitudinal pins for the load cases outlined in Table 1. For purposes of fatigue and to determine range of loading, static waves were placed in such a manner so as to put the platform sections in the maximum hogging and sagging conditions.

The wave shape was a 4.1 foot high sinusoidal wave with lengths, as indicated in Table 1, depending on the relative direction of approach to the platform.

RESULTS SUMMARY, CONCLUSIONS

Attachment 1 is a detailed report of the analysis performed.

Table II summarizes maximum loads in pins and estimated fatigue life for maximum loaded pins. Load cases not filled in were not analyzed.

Load case 5 was not evaluated beyond the still water condition due to maximum stresses being significantly higher that the other cases. It is not recommended that the RRDF be loaded in that configuration.

Load case 4 was not considered further than calm water as indications are it is not a condition likely to occur and due to the short-time duration of this analysis it was considered more productive to look in detail at other cases.

Other load cases not considered were left out due to time constraints.

RESULTS SUMMARY, CONCLUSIONS (cont.)

A static analysis of the RRDF system was performed. The RRDF system will behave dynamically in the prescribed environmental conditions. Although the static analysis includes a 1.25 G factor for the ramp and tank weights, the results of this study may not be conservative. Static analysis is often used in conjunction with empirical knowledge in studying traditional single unit ships and marine structures, but the behavior or articulated multi-piece assemblies is often studied using a dynamic analysis approach or model testing of the articulated units in a multi-directional wave tank. The results of a static analysis should only be considered as a rough order of magnitude that should be substantiated by more refined dynamic analyses and/or testing. The dynamic analysis and testing should be used as a basis for validating the design and safety factors during operation.

The initial analyses assumed that pins connecting the sections together would be uniformly loaded. After reviewing design details and techniques used for assembling RRDF sections it became apparent that pins may in fact be non-uniformly loaded. Thus, an analysis that assumes uniform pin loading would be non-conservative. There are two issues involving the effectiveness of the pin connections: 1) First that some pins are not engaged due to tolerance or distortion problems, and 2) Secondly that the pins that are engaged have different clearances such that load may be distributed to tight connectors only, precluding loading up slack adjacent connectors. It is plausible that some connectors never get loaded and others may take on several times the expected load, thus potentially overloading individual pins that could subsequently cause sequential failure of adjacent connectors. The analysis was conducted making a simplified assumption that all eight (8) pins in each row would be fully engaged and thus take an equal share of the load. From analyses results it appears that the maximum static stress from the analysis model for calm water was in the range of 80 kips, versus design load of 150 kips. If we assume that only 4 pins take the load then the pin loads would be as much as 160 kips exceeding safe operation even in calm water. While it is possible to vary pin loading in conducting the analysis, budget and time constraints precluded such an effort. Verification of uniform connector loading in both still water and at sea conditions should be made prior to conducting at-sea tests of the ramp.

A summary sheet of results is presented in Table 2. The shaded areas represent connector loads that are above the design working load. There are numerous cases of pin overloads in the transverse wave condition. This maximum pin load occurs in a wave-length of 72' which corresponds to a wave period of 3.7 seconds. The fatigue assessment make of the loaded and unloaded platforms indicate that safe operations of the platform is not possible for any reasonable time period required for the at-sea tests in that load condition. The fatigue results are based on uniformly loaded connectors. Non-uniformly loaded connectors will significantly reduce the life of the system.

RESULTS SUMMARY, CONCLUSIONS (cont.)

The analysis shows that the RRDF system as configured is not suitable for ocean conditions where a 4.1 foot wave system is in effect. One of the weak spots in the system is the transverse connector system in the rake end units. With only two connectors on a module of 20' long, versus eight connectors in a module of 40' length (as in the center modules), there is a deficiency in transverse strength, especially in way of the hinges as there are rake end units back-to-back. In trying to get a benchmark of pin loads on at-sea RRDF sections, several load cases were added to the study, namely cases with only the ramp loads considered in both stern-ramp and side-ramp configurations, and also the case with no load at all. Fatigue life results for both these cases were also unacceptable.

Please see the Attachment 1 for more extensive summary sheets of each load condition. Appendix B of Attachment 1 contains the equilibrium calculation sheets which also provide a longitudinal graphic depiction of the sections on the wave for each loading case and wave condition analyzed. Appendix C of Attachment 1 contains additional load output sheets which show the axial loads on the pins for all pin locations at the deck level, also for all load conditions.

LAKE SHORE INC. - RRDF ANALYSIS - SUMMARY OF LOAD CONDITIONS

TABLE 2

LOADS IN KIPS

LC NO.	LOAD DESCRIPTION	SEA CONDITION													
		CALM		TRANSVERSE 72' WAVE				DIAGONAL 100' WAVE				LONGITUDINAL 100' WAVE			
		CALM	CYCLES	TRAN-1	TRAN-2	RANGE	HRS.	DIAG1	DIAG2	RANGE	HRS.	LONG1	LONG2	RANGE	HRS.
STERN RAMP CONFIG. - RAMP CENTERED															
LSC1	TWO TANKS ON RAMP	61	133 K	121	58	106	26	63	89	77	80	88	76	87	56
LSC2	ONE TANK ON RAMP - ONE TANK JUST OFF RAMP	74	73 K	160	54	136	12								
LSC8	ONE TANK ON RAMP - ONE TANK FURTHER OFF RAMP			166	55	136	12								
LSC3	TWO TANKS OFF RAMP - CENTERED ON HINGE	80	58 K	167	56	135	13								
LSC4	TWO TANKS OFF RAMP - STBD SIDE INBOARD RRDF	70	86 K												
STERN RAMP CONFIG. - RAMP MOVED 20' OUTBOARD															
LSC5	TWO TANKS ON RAMP	114	20 K	162											
SIDE RAMP CONFIG.															
LSC6	TWO TANKS ON RAMP	75	70 K	122	81	112	22								
LSC7	TWO TANKS OFF RAMP-CENTERED INBD END INBD RRDF	72	79 K	183	60	183	5								
NO TANK CONFIG.															
LSC9	STERN RAMP CONFIG.			96	57	96	35	59	67	60	172	59	43	58	185
LSC10	SIDE RAMP CONFIG.			109	75	109	24								
NO TANKS OR RAMP															
LSC11	NO LOAD ON RRDF			96	64	96	35	62	59	21	3736	48	47	48	329

* *SHADED CELLS INDICATE LOADS ABOVE DESIGN WORKING LOAD.*

REVISION STATUS OF SHEETS						REVISIONS				
					1	ZONE	REV	DESCRIPTION	DATE	APPROVED
					–	–	–	INITIAL ISSUE	96/08/16	WJK

SH 1 E30405 DWG NO

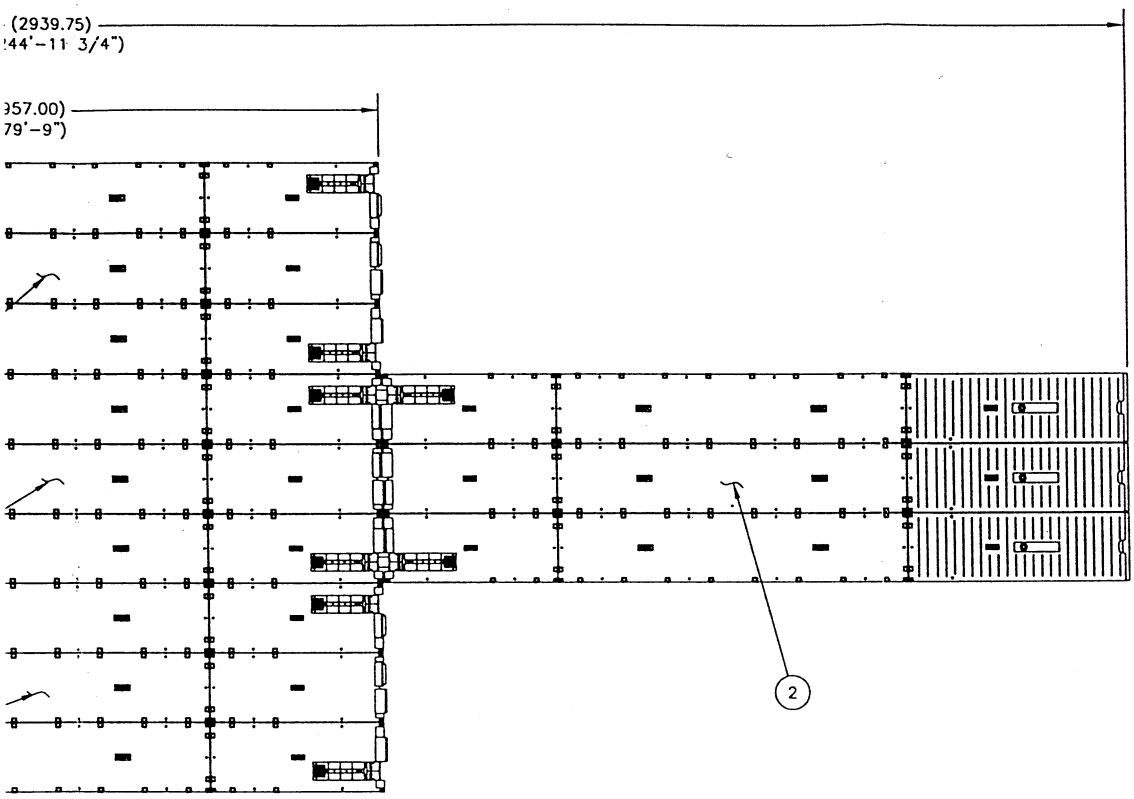


FIGURE 1
TO REPORT
DAAK01-96-P-0219

IT NO	QTY REQ	CAGE CODE	PART OR IDENT NO	NOMENCLATURE	DESCRIPTION	MATERIAL		WT	ZONE
2	1	–	E19183	–	BEACH/SEA END SECTION	–	WT. 140,184#	–	B-3
1	6	–	E19193	–	INTERMEDIATE SECTION	–	WT. 134,786#		A-7

PARTS LIST

NEXT ASSEMBLY	USED ON
–	–

APPLICATION

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES
TOLERANCES:

X.X ± .06
X.XX ± .03
X.XXX ± .015
ANGLES ± 1° 30'

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED IN DOD-D-1000B

DO NOT SCALE THIS DRAWING

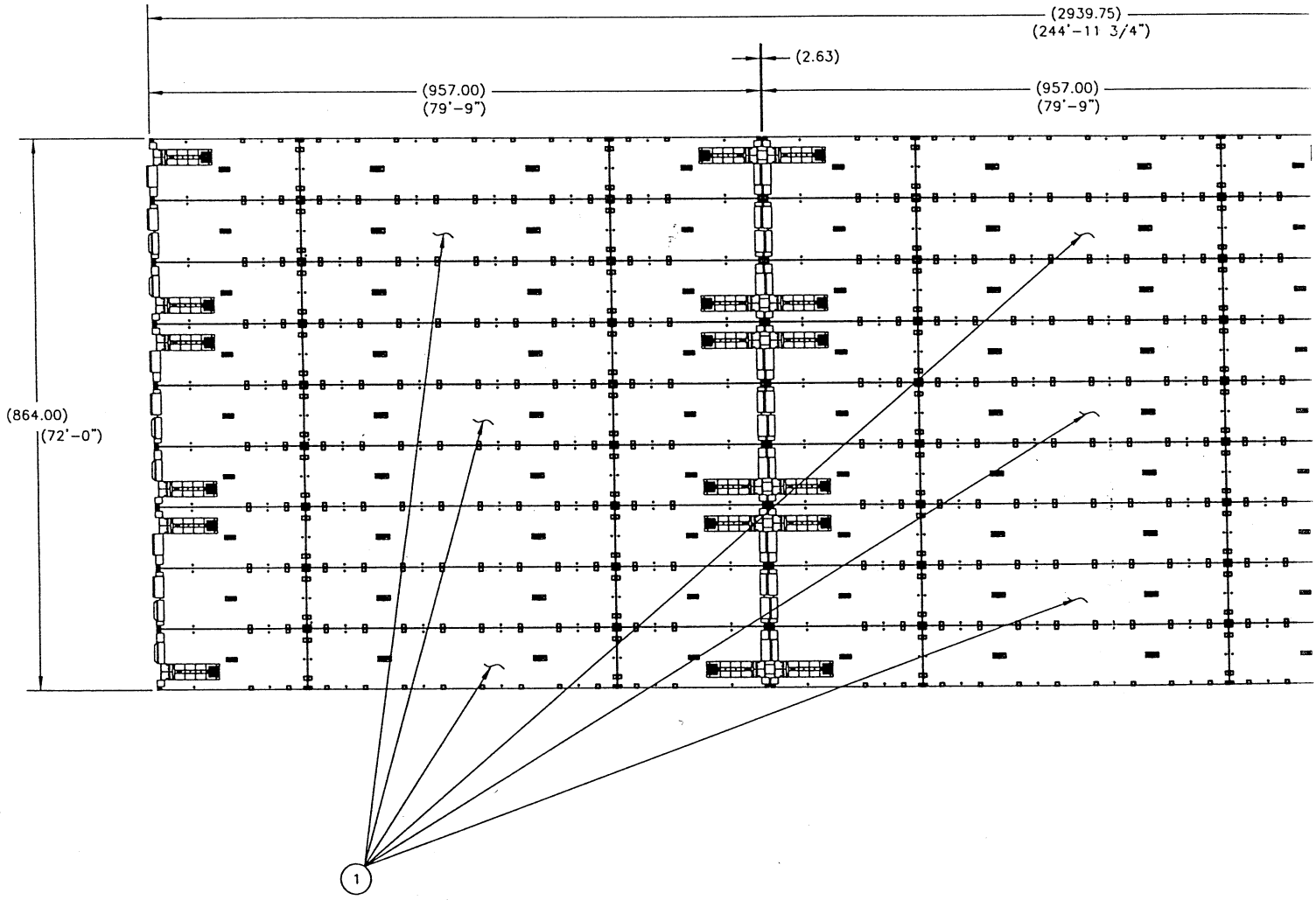
DRAWN	EWR	96/08/16
CHECK	WJK	96/08/16
APP	WJK	96/08/16

LAKE SHORE INC.
AN OLDENBURG GROUP COMPANY ROCKVILLE, MICHIGAN 48801

TITLE MCF RO/RO PLATFORM OUTLINE

SIZE	CAGE CODE	DWG NO	REV
D	34712	E30405	–

SCALE – WT 948,900 LBS SHEET 1 OF 1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